Oak Ridge National Laboratory
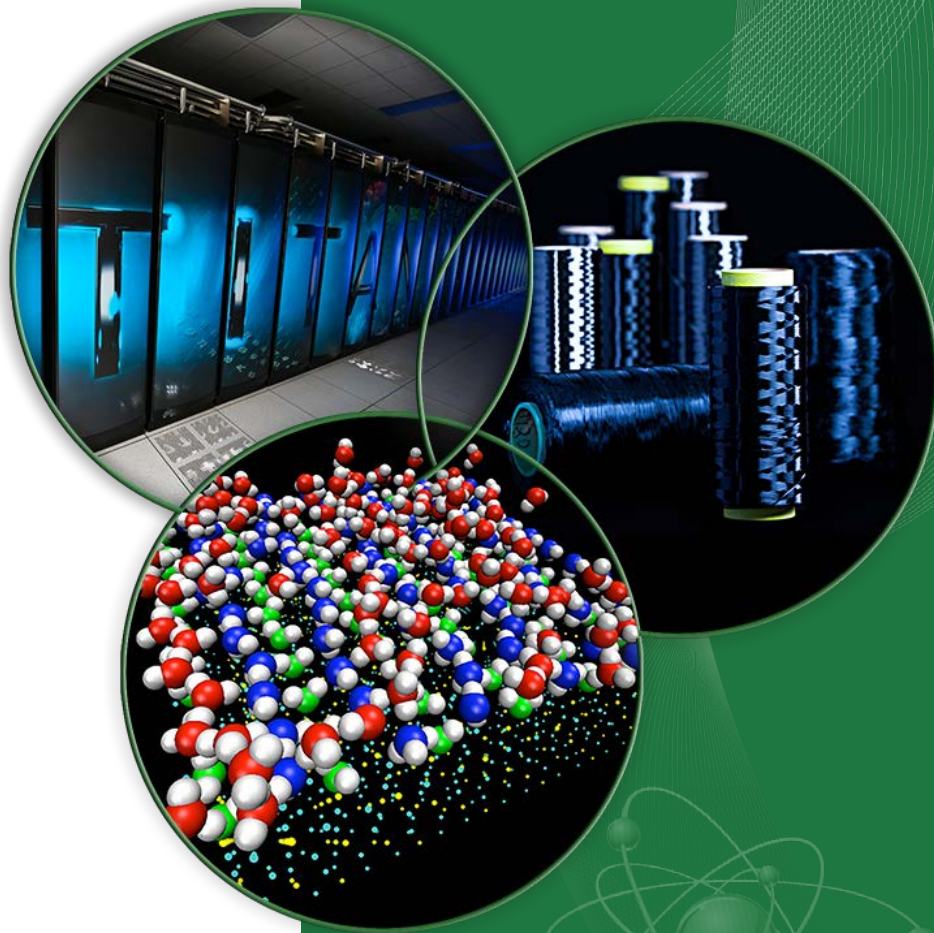**Computing and Computational Sciences Directorate**

Identifying a Few, High Leverage Energy Efficiency Metrics

Neena Imam

SC15, November 19, 2015

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Why Yet Another BoF?

Executive Order: EO 13693

Mandates that all federal agencies must implement energy conservation measures.

ii) improving data center energy efficiency at agency facilities by:

(A) ensuring the agency chief information officer promotes data center   energy optimization, efficiency, and performance;
(B) installing and monitoring advanced energy meters in all data centers by fiscal year 2018; and
(C) establishing a power usage effectiveness target of 1.2 to 1.4 for new data centers and less than 1.5 for existing data centers;
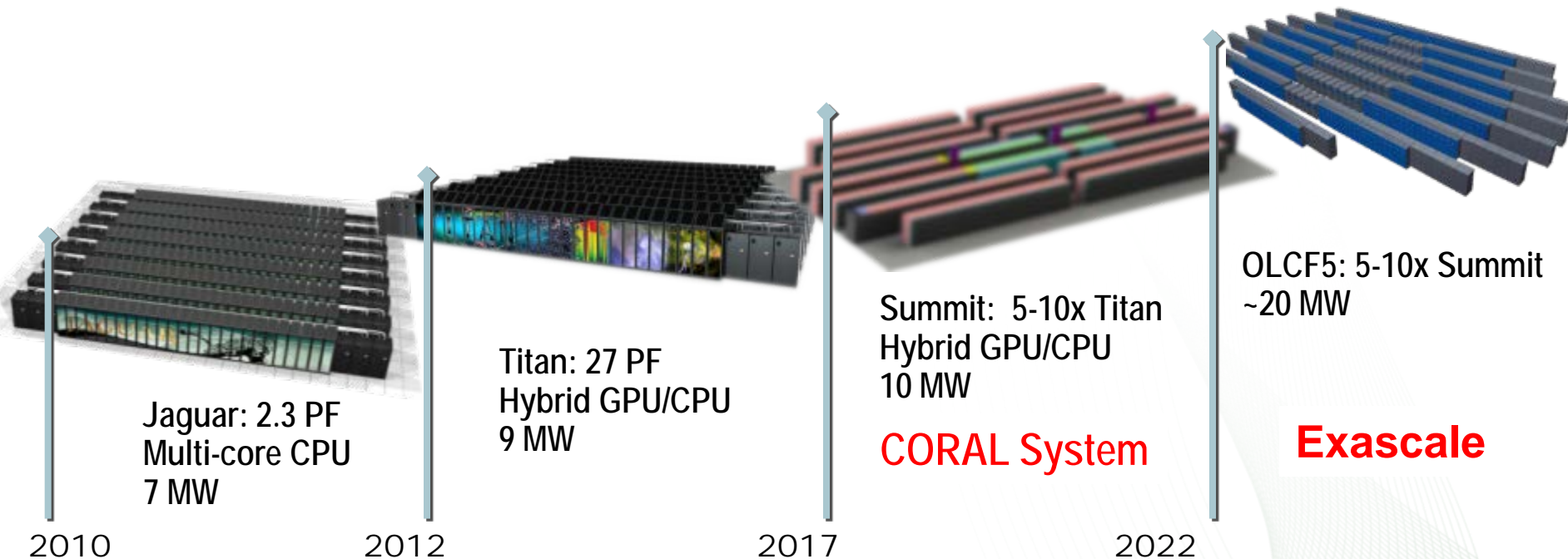
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Why Yet Another BoF?

- Supercomputers are power constrained
  - Exaflop operation to be achieved with 20MW power budget.

- Supercomputers are expensive
  - Power is expensive. Operating cost of supercomputers are now comparable to the acquisition cost.

- High power consumption ⟹ high operating Temp ⟹ less resiliency

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Can Supercomputers be Energy Efficient?

Since clock-rate scaling ended in 2003, HPC performance has been achieved through increased parallelism. Jaguar scaled to 300,000 cores.

Titan and beyond deliver hierarchical parallelism with very powerful nodes. MPI plus thread level parallelism through OpenACC or OpenMP plus vectors

OLCF5: 5-10x Summit ~20 MW

Summit: 5-10x Titan Hybrid GPU/CPU 10 MW

CORAL System

Titan: 27 PF Hybrid GPU/CPU 9 MW

Jaguar: 2.3 PF Multi-core CPU 7 MW

Exascale

2010   2012   2017   2022

Source: Jeff Nichols, ORNL, Directorate Advisory Committee Meeting, 2014

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Metrics

- **Metrics measure performance and activities**

- **We can't manage what we don't measure**

- **Exposes trends over time**

- **Comparison between different sites**

- **Regulation and policies**

- **Short and long term objectives**

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The Three Well Known Metrics

- **PUE (Power Usage Effectiveness)**
  - ❖ **widely adopted, not perfect**
- **ITUE (IT-power usage effectiveness)**
  - ❖ **similar to PUE but "inside" the IT**
- **TUE (total-power usage effectiveness)**
  - ❖ **total efficiency picture**

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Other Metrics

- **CUE – Carbon Usage Effectiveness**
  - **impact of carbon usage in the operation of data centers.**

- **WUE – Water Usage Effectiveness**
  - **impact of water usage in data centers**

- **Trapped capacity and stranded capacity as metrics**

- **TCO: Total Cost of Ownership**

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How To Socialize New Metrics

- **Managing power is a shared responsibility between all users, data center managers, IT and infrastructure designers, and Operations and Management**

- **After community consensus, new metrics should be included in RFPs and SOWs for Vendors**

- **Improved monitoring tools are needed**

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Related Activities at ORNL

- **Developing improved power monitoring tools: you cannot control something that you cannot measure**

- **Monitoring tools to measure trapped capacity**

- **1st Workshop on HPC Power Management (HPM 2015)**

- **Novel research in terms of power aware scheduling, application power signature analysis, predictive analytics**

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